High-p_T Hadron Spectra, Azimuthal Anisotropy and Back-to-Back Correlations in High-energy Heavy-ion Collisions

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The degradation of high-p_T partons during their propagation in the dense medium can provide critical information necessary for detection and characterization of the strongly interacting matter produced in high-energy heavy-ion collisions. Because of radiative parton energy loss induced by multiple scattering, the final high-p_T hadron spectra from jet fragmentation are expected to be significantly suppressed. Such a phenomenon, known as jet quenching, was observed for the first time in $Au+Au$ collisions at the Relativistic Heavy-ion Collider (RHIC). One also observes the disappearance of back-to-back jet-like hadron correlations and finite azimuthal anisotropy of high-p_T hadron spectra. These three seemingly unrelated high-p_T phenomena are all predicted as consequences of jet quenching. Together, they can provide unprecedented information on the properties of dense matter produced at RHIC.

In this Letter [1], we will study these three high-p_T phenomena simultaneously within a lowest order (LO) pQCD parton model that includes initial nuclear k_T broadening, parton shadowing and medium induced parton energy loss. We point out that an enhanced $(K+p)/\pi$ ratio leads naturally to different suppression of $h^\pm$ and π^0 spectra at intermediate p_T range. We will also show that the suppression of back-to-back correlations is directly related to the medium modification of hadron-triggered FF's similar to a direct-photon triggered FF.

Shown in Fig. 1 are the calculated nuclear modification factors $R_{AB}(p_T) = d\sigma^h_{AB}/\langle N^{AB}_{\rm bin}\rangle d\sigma^h_{pp}$ for hadron spectra ($|y| < 0.5$) in $Au+Au$ collisions at $\sqrt{s} = 200$ GeV, as compared to experimental data. Here, $\langle N^{AB}_{\rm bin}\rangle = \int d^2b d^2r t_A(r) t_B(|\vec{b}-\vec{r}|)$. To fit the observed π^0 suppression in the most central collisions, we have used (solid lines) $\mu_0 = 1.5$ GeV, $\epsilon_0 = 1.07$ GeV/fm and $\lambda_0 = 1/(\sigma\rho_0) = 0.3$ fm with the new HIJING parameterization of parton shadowing. The hatched area (also in other figures in this paper) indicates a variation of $\epsilon_0 = \pm 0.3$ GeV/fm. The hatched boxes around $R_{AB} = 1$ represent experimental errors in overall normalization. Alternatively, one has to set $\mu_0 = 1.3$ GeV and $\epsilon_0 = 1.09$ when EKS parameterization of parton shadowing is used (dot-dashed lines). Without parton energy loss, the spectra is slightly enhanced at $p_T = 2-5$ GeV/c due to nuclear k_T broadening even with parton shadowing. This effect due to k_T smearing will disappear above $p_T > 5$ GeV

We have studied simultaneously the suppression of hadron spectra and back-to-back correlations, and high-p_T azimuthal anisotropy in high-energy heavy-ion collisions within a single LO pQCD parton model in-

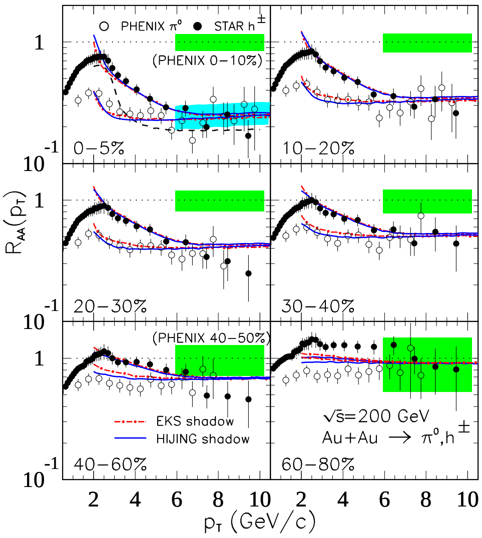

FIG. 1: Nuclear modification factors for hadron spectra in $Au+Au$ collisions as compared to data from STAR and PHENIX .

corporating current theoretical understanding of parton energy loss. Experimental data of $Au+Au$ collisions from RHIC can be quantitatively described by jet quenching in an expanding medium. With HIJING (EKS) parton shadowing, the extracted average energy loss for a 10 GeV quark in the expanding medium is $\langle dE/dL\rangle_{1d} \approx 0.85(0.99) \pm 0.24$ GeV/fm, which is equivalent to $dE_0/dL \approx 13.8(16.1) \pm 3.9$ GeV/fm in a static and uniform medium over a distance $R_A = 6.5$ fm. This value is about a factor of 2 larger than a previous estimate because of the variation of gluon density along the propagation path and the more precise RHIC data considered here .

[1] X.-N. Wang, Phys. Lett. **B595**, 165 (2004), nucl-th/0305010.